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ABSTRACT

This study was designed to investigate whether a student's responses to test questions about natural selection were influenced by the extent of the student's identification with the organism. The hypothesis was that a student would be reluctant to invoke the ravages of natural selection upon species with which they possessed a greater empathy than upon species about which they cared less strongly. College students (n=130) in a general biology course at a major research university were administered a twelve-item multiple choice test after the evolution instructional unit had been completed to assess their understandings of natural selection, The test consisted of six parallel items with the difference between parallel items being only in the type of organism described. Analyses were conducted to evaluate whether students made disproportionately greater errors on those items describing organisms with which they more closely identified. Results show that approximately 20% of students' responses were correct on one of two parallel test items demonstrating a substantial number of students responding in a discrepant manner. The students were presented with lists of organisms and asked to rank their relative regard for the organisms. The preference rankings were cross-tabulated with scores on the test items; however, the preference rankings failed to explain the discrepancies in students' responses. The data do not support the existence of a Disney effect. One version of the test is included in an appendix. Contains 15 references (Author/JRH)

Investigating The Disney Effect: Are Students Reluctant To Apply Natural Selection Principles To Life Forms With Which They Identify?

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Abstract

This study was designed to investigate whether a student's responses to test questions about natural selection were influenced by the extent of the student's identification with the organism. The hypothesis was that a student would be reluctant to invoke the ravages of natural selection upon species with which they possessed a greater empathy than upon species about which they cared less strongly. College students in a general biology course at a major research university were administered a twelve-item multiple choice test to assess their understandings of natural selection. The test consisted of six parallel items with the difference between parallel items only in the type of organism described. Students were asked to individually rank lists of organisms according to their relative "preference" for each organism. Analyses were conduced to evaluate whether students made disproportionately greater errors on those items describing organisms with which they more closely identified.

Introduction

This study was designed to investigate whether a student's responses to test questions about natural selection were influenced by the extent of the student's identification with the organism. The hypothesis was that a student would be reluctant to invoke the ravages of natural selection upon species with which they posses a greater empathy than upon species about which they cared less strongly. This "pulling for the furry guy" outlook is being called the Disney effect.

Several studies examining students understanding of evolution by natural selection have appeared in the science education research literature (Bishop & Anderson, 1990; Demastes, Settlage, & Good, 1995; Jensen & Finley, 1995; Settlage, 1994; Settlage & Odom, 1995; Tamir & Zohar, 1991). An overriding theme in the studies is that students' explanations of evolution draw from a complex mixture of ideas relating to Lamarckian evolution, Darwinian evolution, and teleology and also the students' conceptions are resilient to change (Deadman & Kelly, 1978; Brumby, 1979; Halldén, 1988). To compound the problem further, students respond to questions about natural selection in different ways depending upon the species describe in the test questions. For example, Demastes, Good, and Peebles (1995) found that during individual interviews, high school students became, over one school year, more capable at applying evolutionary principles to various scenarios. However, some students were reluctant to extend the possibility of natural selection to include humans. This suggests, at least to these authors, that students struggle to apply the principle of "survival of the fittest" to organisms that are perceived as more like themselves.

The history of classification schemes can provide some insight into what humans consider to be more and less like themselves. The Great Chain of Being depicted nature as a highly structured system based on a hierarchical, linear patterns (Bowler, 1983). The hierarchy displayed humans at the top (most superior) and inert items at the bottom (Appendix 1). This classification scheme was initially developed by the Greeks and was extensively used into the early 1800s. One intent of the chain was to show the divine plan of creation; a very orderly, well thought-out design. Each species represented a vital link in the chain and extinction represented a break in the sequence;

a flaw in the design. Because of this, many supporters of the chain model doubted the likelihood that a whole species could ever be abolished. The Chain of Being model lost popularity when more and more species were discovered and the relationships between them could no longer be explained via a simple linear hierarchy (Gould, 1985).

Though the Chain of Being is not taught in most biology courses, students still identify organisms as being more and less like humans, and it is our assumption that the closer a student identifies an organism to humans, the less likely they perceive the organism to encounter negative effects from natural selection. For example, students relying upon a Great Chain of Being mindset might feel dogs would be less effected by a selection event than a bacteria because dogs posses more human qualities; they're closer to the top of the chain than are bacteria.

We predict the existence of the Disney effect for two reasons. First, students have been found to recapitulate historical views in their own explanations of natural phenomena (Wandersee, 1985; Jensen and Finley, 1995) and remnants of ideas about the Chain of Being are still present in our language, e.g., "advanced" and "primitive." For many students the term "advanced" relates to intelligence (the ability to out-smart natural selection) and/or morphological complexity whereas "primitive" implies an organism's relative simplicity making it a more plausible target for selection events.

The second reason the existence of the Disney effect is predicted is the prevalent anthropomorphic depictions of animals in popular media. Children's movies and stories frequently portray nature in unrealistic terms: predators rarely eat but still survive, potential prey (such as Bambi and other Disney-like characters) avoid selection events, and death is underrepresented. Hundreds or even thousands of examples of inaccuracies can be found in children's literature all potentially influencing students' views of nature prior to entering a biology course.

Method

Two groups of general biology students at a large midwestern research university were administered a twelve-item multiple choice test (version B of the two-tier test "Understanding Biological Change" (Settlage & Odom, 1995)) to assess the extent of their understanding of natural selection. (See Appendix 2 for a copy of the tests.) The test consisted of six parallel items describing evolutionary scenarios. The difference between parallel items was in the life form depicted in the scenario (see Figure 1). One group of students was taught during the spring of 1995 (n=51) and the other was taught during the fall of 1995 (n=79). The evaluation took place, in both sections, at the end of the quarter after the evolution instructional unit had been completed.

Figure 1: Sample parallel test items from the Understanding Biological Change test, version B (Settlage & Odom, 1995).

Question 4: Seals

Seals that live in Alaska have a fat layer. Their ancestors may not have had fat as thick as it is today. Over the centuries, changes in the seals have occurred since:

1. the need to keep warm caused the fat of every seal to get thicker,
2. more seals each generation have had thicker fat,

BECAUSE

A. the seals wanted to adapt to their surroundings.
B. the offspring inherited a thicker layer of fat from their parents.
C. the few individuals that had a thicker fat layer lived to produce offspring.

Question 10: Bats

Bats that feed at night have a very sophisticated sense of hearing. Their ancestors may not have heard as well as bats of today. Over the centuries, changes in the bats have occurred since:

1. the need to feed at night caused the hearing sense of every bat to increase,
2. more bats each generation have had better hearing,

BECAUSE

A. the bats wanted to adapt to their surroundings.
B. the offspring inherited better hearing from their parents.
C. the few individuals that had better hearing lived to produce offspring.

After responding to the twelve two-tier test items, the students were presented with six lists of organisms. Each list contained four organisms, two of which appeared in the test as parallel test items (the other two organisms within each foursome were from version A of the Understanding Biological Change test). For three lists, the students were to rank the organisms on the basis of the relative appeal. The students were free to interpret the term "appeal" however they wished. On the other three lists, the students were to rank the sets of four organisms according to how "advanced" they felt the organisms were relative to each other. The intention of the ranking activity was to identify each students' disposition toward the organisms in the natural selection scenarios provided in the test items. There was some uncertainty about whether the Disney effect, if it in fact existed, could be attributed to an individual's affection for one organism over another or because the individual had a greater regard for one organism because it held residence higher on the Great Chain of Being. The decision to ask for both "appeal" and "advancement" rankings was intended to investigate both possibilities.

Responses on the two-tier items were subjected to chi-square analyses. Six separate tables were constructed, one for each pair of parallel test items. Student responses were considered correct when they selecte the desired response on both tiers. Data was coded dichotomously, right or wrong. A total of 130 tests provided usable data. The frequencies in the 2 X 2 tables reflected how consistently the students responded to parallel items (see Tables 1 & 2). Student responses were not randomly distributed: chi-squared values (df=1) ranged from 27.607 to 57.767, all of which were significant ($p < .001$).

Table 1: Distribution of responses to parallel items on Understanding Biological Change test, version B (n = 130).

A

		Bullfrogs 0	Bullfrogs 1	TOTAL
Sharks	0	50	15	65
	1	7	58	65
	TOTAL	57	73	130

D

		Bats 0	Bats 1	TOTAL
Seals	0	40	15	55
	1	14	61	75
	TOTAL	54	76	130

B

		Butterflies 0	Butterflies 1	TOTAL
Birds	0	31	9	40
	1	21	69	90
	TOTAL	52	78	130

E

		TB bacteria 0	TB bacteria 1	TOTAL
Locust	0	50	17	67
	1	18	45	63
	TOTAL	68	62	130

C

		Evergreens 0	Evergreens 1	TOTAL
Raccon	0	55	22	77
	1	8	45	53
	TOTAL	63	67	130

F

		Lizard 0	Lizard 1	TOTAL
Moth	0	16	6	22
	1	16	92	108
	TOTAL	32	98	130

Table 2: Frequency of discrepant responses to parallel items on Understanding Biological Change test, version B (n = 130).

Parallel items	Frequency	Percent
A	22 / 130	16.9%
B	30 / 130	23.1%
C	30 / 130	23.1%
D	29 / 130	22.3%
E	35 / 130	26.9%
F	22 / 130	16.9%
Totals	168 / 780	21.5%

Examining the data tables suggests the students were fairly consistent in their success on parallel items. For the six pairs of parallel items, the number of students who were correct on one item but not on its partner ranged from 22 (16.9%) for item pairs A and E to 35 (26.9%) for item pair E. In other words, the pattern of student responses indicates the instrument was reliable because no less than 70% of responses to both items right or both items wrong on the parallel items. In fact statistics support this speculation; reliability for Version B of Understanding Biological Change test, when calculated as a Spearman-Brown coefficient, was 0.835.

Although the instrument proved to be highly reliable, the number of students who had differential success on parallel items was substantial (21.5%); subsequent analyses were based upon these particular respondences. For this analysis, the students' "appeal" and "advance" rankings were used. Whenever a student had selected the correct response on one item but not the other in a parallel pair, their rankings of the organisms was selected. In spite of the initial intention to keep "advance" and "appeal" rankings separate, the attenuated sample size precluded this desire. Consequently, the decision was made to collapse rankings into relative "preference" and continue the statistical analyses without maintaining the distinctions.

For all discrepant responses, the relative rankings for the organisms included in the particular items were examined. The organism that received the higher ranking was considered "preferred" regardless of the difference in the values ascribed to the organisms. In other words, one organism was coded as preferred over the other if its ranking was small (2 versus 3) or large (1 versus 4). Because some students did not provide decipherable responses to the ranking component of the test, the sample size was further reduced.

The data were arranged into 2 X 2 tables and subjected to a chi-square analysis (see Figure 2). Recall that the Disney effect posits that students will be less likely to apply natural selection principles to organisms with which they have greater empathy. If a student possesses a preference for Organism #1, then their response on this pair of parallel items would fall in the first row. Furthermore, if the Disney effect is at work, then hypothetically the student would be more likely to NOT select the correct answer on the test item that describes that organism (cell B). Likewise, should a student express a preference for Organism #2 and is subconsciously reluctant to employ natural selection to explain its evolution, that student's response would be categorized into cell C.

If the Disney effect actually explain the discrepancy in individual's responses, we would expect a smaller frequencies for cells A and D and greater frequencies in cells B and C.

Figure 2: Generic frequency table designed to investigate for the presence of the Disney effect.

		Correct response ONLY on parallel test item that describes	
		Organism #1	**Organism #2**
Preference for	**Organism #1**	**A**	**B**
Preference for	**Organism #2**	**C**	**D**

Results

Results of the chi-square analysis are shown in Table 3. The chi-square values for the six tables ranged from 0.00 to 0.89 (df=1). None of these value represent a statistical significance (p values from 0.344 to 1.00). These data do not support the existence of a Disney effect.

Table 3: Cross tabulations of students' tests with contradictory success on parallel items compared to their preferences.

Q1 and Q7 — Correct answer only for

	shark	frog	
Prefer shark	6	12	18
Prefer frog	1	2	3
	7	14	21

chi-square = 0.000, p = 1.000, 1 d.f.

Q4 and Q10 — Correct answer only for

	seal	bats	
Prefer seal	10	9	19
Prefer bats	4	5	9
	14	14	28

chi-square = 0.164, p = 0.686, 1 d.f.

Q2 and Q8 — Correct answer only for

	legs	bflies	
Prefer legs	9	5	14
Prefer bflies	12	3	15
	21	8	29

chi-square = 0.895, p = 0.344, 1 d.f.

Q5 and Q11 — Correct answer only for

	locst	TB	
Prefer locust	6	6	12
Prefer TB	12	9	21
	18	15	22

chi-square = 0.157, p = 0.692, 1 d.f.

Q3 and Q9 — Correct answer only for

	rcoon	evrgr	
Prefer rcoon	4	13	17
Prefer evrgr	3	9	12
	7	22	29

chi-square = 0.008, p = 0.927, 1 d.f.

Q6 and Q12 — Correct answer only for

	moth	lizard	
Prefer moth	4	1	5
Prefer lizard	11	5	16
	15	6	21

chi-square = 0.236, p = 0.627, 1 d.f.

Discussion

College students enrolled in a general biology course took a two-tier test designed to assess conceptions of evolution by natural selection. Approximately 20% of students' responses were correct on one of two parallel tests items demonstrating a substantial number of students responding in a discrepant manner. It was hypothesized that the students might have responded differently on items because of an intrinsic regard for the organisms depicted in the test items; this proposed factor was called the Disney effect. The students were presented with lists of organisms and asked to rank their relative regard for the organisms. Rankings were converted to determine which organism for each pair of parallel items was preferred. The rankings were cross-tabulated with scores on the test items.

The preference rankings failed to explain the discrepancies in students' responses. The data revealed that although approximately twenty percent of the responses were inconsistent (i.e., one item was correct while the other was incorrect) the rankings did not sufficiently explain the differences. The question about why one out of every five sets of responses to parallel items are not identical remains open and unanswered. At this stage, there is no clear explanation for the situation described here which, in turn, had been prompted by previous research upon students' misconceptions about natural selection.

The degree to which a students finds the theory of evolution via natural selection to be "believable" fails to explain the data presented here. First, while from 16 to 55 of the respondences were incorrect on both items in a pair, the responses selected for analysis included students who were correct on one of the two items in a pair. A rejection of the idea of evolution by an individual would not account for this pattern. Second, no hard evidence has appeared in the literature suggesting that any relationship exists between religious beliefs and ability to understand natural selection.

In the next study, the Biological Change Test will be used prior to any instruction on evolution, and will be utilized to identify students who responds differentially to multiple parallel items. Those individual will then be interviewed before, during, and after the evolution instructional unit. Data from this study will hopefully provide a robust data source from which a detailed picture of a students' understanding of evolution may be derived.

Appendix 1 -- The Chain of Being after Charles Bonnet's mid-1700s ranking (excerpted from Bowler (1983)).

Highest	Man
	Monkeys
↓	Quadrupeds (Mammals)
	Bats
	Ostrich
↓	Birds
	Aquatic Birds
	Flying Fish
↓	Fish
	Eels
	Sea Serpents
↓	Reptiles
	Slugs
	Shellfish
↓	Insects
	Worms
	Polyps
↓	Sensitive Plants
	Trees
	Shrubs
↓	Herbs
	Lichens
↓	Mold
	Minerals
	Earth
↓	Water
	Air
Lowest	Etherial Matter

Appendix 3

Understanding Biological Change, Form B

version 0.8 *

April 20, 1994

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DIRECTIONS

Each question on this test contains two parts. Your response to the first part involves selecting the option that best completes the phrase. These options are indicated with a 1 or a 2. The second part asks you to select the reason for the choice you made in the first part. After the word "BECAUSE" you will find three choices marked with A, B or C. Choose the reason that best matches your understanding.

You response to each item will consist of a two part answer. On the blank next to each item, you are to write the number and letter that best matches your understanding of biological change.

EXAMPLE

The energy in almost every food chain can be traced back to:

1. the Sun
2. insects

BECAUSE:

A. more animals belong to this group than to any other.
B. plants absorb their energy from the soil.
C. photosynthesis is the first step in most food chains.

Explanation The Sun is the correct answer for the first part. Even though reason A is a true statement, it is not the reason that best matches the first half of the question. Reason B seems to match with the Sun, except that soil provides minerals for plants, not energy. Therefore, the complete correct response is 1C.

Sharks

Modern day sharks can swim at speeds up to 30 knots. Suppose their ancestors swam at a much slower speed. The ability to swim fast probably:

1. developed for all the sharks in a few generations,
2. involved an increase in the percentage of sharks that can swim faster,

BECAUSE:

A. there was first a random genetic change in a few individuals.
B. the more the sharks used their muscles, the faster they became.
C. the need to catch prey caused them to swim faster.

Birds

Birds with long legs can feed in watery regions much better than can birds without long legs. If a large population of birds without long legs were transported to a remote island covered with very little dry land and lots of marshes, swamps, and ponds:

1. some birds would live and some would die,
2. the birds would gradually develop long legs,

BECAUSE:

A. all of the birds' legs would slowly change so they would be better for feeding.
B. the few birds starting out with longer legs would survive to reproduce.
C. the legs of every bird would change in the same way since they are all related.

Raccoons

A population of raccoons exists in an area that has had several years of very cold winters. If the winters continue to be severe in the future, we would expect that:

1. most of the raccoons will be able to live through the winter,
2. many of the raccoons will live but some will freeze to death,

BECAUSE:

A. some individuals, by chance, have thicker fur than others.
B. the raccoons will adapt to the cold weather.
C. the need to survive the cold will cause the raccoons to develop thicker fur.

Seals

Seals that live in Alaska have a fat layer. Their ancestors may not have had fat as thick as it is today. Over the centuries, changes in the seals have occurred since:

1. the need to keep warm caused the fat of every wolf to get thicker,
2. more seals each generation have had thicker fat,

BECAUSE:

A. the seals wanted to adapt to their surroundings.
B. the offspring inherited a thicker layer of fat from their parents.
C. the few individuals that had thicker fat layer lived to produce offspring.

Locusts

Many years ago, the spread of locusts was controlled with the chemical DDT. Recently, chemists have found that locusts do not seem to be harmed as much by the DDT. The reason for this change is that:

1. a greater number of locusts each generation are unaffected by the DDT,
2. over the years, all of the locusts gradually became less affected by DDT,

BECAUSE:

A. every generation, the individual locusts who survived the DDT had offspring.
B. the need to survive caused the locusts to change.
C. the use of DDT led to a mutation of the DNA in the locusts.

Moths

A population of moths contains individuals that have either light or dark colored bodies. The forest where the moths live used to have trees with both light and dark trunks. Recently, a disease has wiped out all of the types of trees except those with the darkest trunks. The effect on the moths would be that every generation:

1. the light colored moths would develop slightly darker bodies,
2. there would be a greater proportion of dark moths in the population,

BECAUSE:

A. the moths would adapt to the change in the environment.
B. the need to survive would cause the moths to shift their color.
C. only those moths with dark bodies would escape predators and live to reproduce.

Bullfrogs

Bullfrogs can jump over 10 feet in a single hop. Suppose that the bullfrogs alive today had ancestors that could not jump as far. The ability to hop large distances probably:

1. developed for all the bullfrogs in a few generations,
2. involved an increase in the percentage of bullfrogs that could hop far,

BECAUSE:

A. the more that bullfrogs used their muscles, the further they could jump.
B. there was first a random genetic change in a few individuals.
C. the need to avoid predators caused them to jump further.

Butterflies

Butterflies with a long proboscis (feeding tube) can reach the nectar at the base of flowers better than can butterflies with shorter proboscis. Some flowers have shallow tubes with nectar at the bottom while other flowers have much deeper and narrower tubes. If a large population of butterflies with short proboscis were transported to a desert oasis covered entirely with plants whose flowers had very long tubes:

1. some butterflies would live and some would die,
2. the butterflies would gradually develop longer proboscises,

BECAUSE:

A. the few butterflies starting out with longer proboscises would survive to reproduce.
B. the proboscis of every butterfly would change in the same way since they are all related.
C. all of the butterflies' proboscises would slowly change so they would be better for reaching the nectar.

Evergreens

A population of evergreens exists in an area that has had several years of very hot and dry summers. If the summers continue to be severe in the future, we would expect that:

1. many of the evergreens will live but some will die because of the dryness,
2. most of the evergreens will be able to live through the summer,

BECAUSE:

A. the need to survive the summers will cause the evergreens to develop better ways to avoid drying out.
B. some individual evergreens have, by chance, better ways of conserving water.
C. the plants will adapt to the hot and dry weather.

Bats

Bats that feed at night have a very sophisticated sense of hearing. Their ancestors may not have heard as well as bats of today. Over the centuries, changes in the bats have occurred since:

1. the need to feed at night caused the hearing sense of every bat to increase,
2. more bats each generation have had better hearing,

BECAUSE:

A. the bats wanted to adapt to their surroundings.
B. the offspring inherited better hearing from their parents.
C. the few individuals that had better hearing lived to produce offspring.

Tuberculosis (TB) bacteria

Many years ago, bacteria that caused TB were controlled with a combination of three antibiotics. Recently, doctors have found that TB bacteria do not seem to be harmed as much by the three antibiotics. The reason for this change is that:

1. over the years, all of the bacteria gradually became less affected by penicillin,
2. a greater proportion of bacteria are unaffected by the penicillin each generation,

BECAUSE:

A. the need to survive caused the bacteria to change.
B. the use of antibiotics led to a mutation of the DNA in the bacteria.
C. every generation, the individual bacteria who survived the antibiotics reproduced.

Lizards

A population of lizards contains individuals that have either solid green or green-striped bodies. The region where the lizards live used to have grass plants with both solid green and green-striped leaves. Recently, a disease has wiped out all of the types of grass except those with the solid green leaves. The effect on the lizards would be that every generation:

1. the green-striped lizards would develop slightly less striped bodies,
2. there would be a greater proportion of individuals with solid green bodies,

BECAUSE:

A. only those lizards with solid green bodies would escape predators and live to reproduce.
B. the lizards would adapt to the change in the environment.
C. the need to survive would cause lizards to change their body color.

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